

# **Impacts of Nutrients on the Biological Integrity of Streams and Rivers: Information to help refine Nutrient Criteria for Wisconsin**

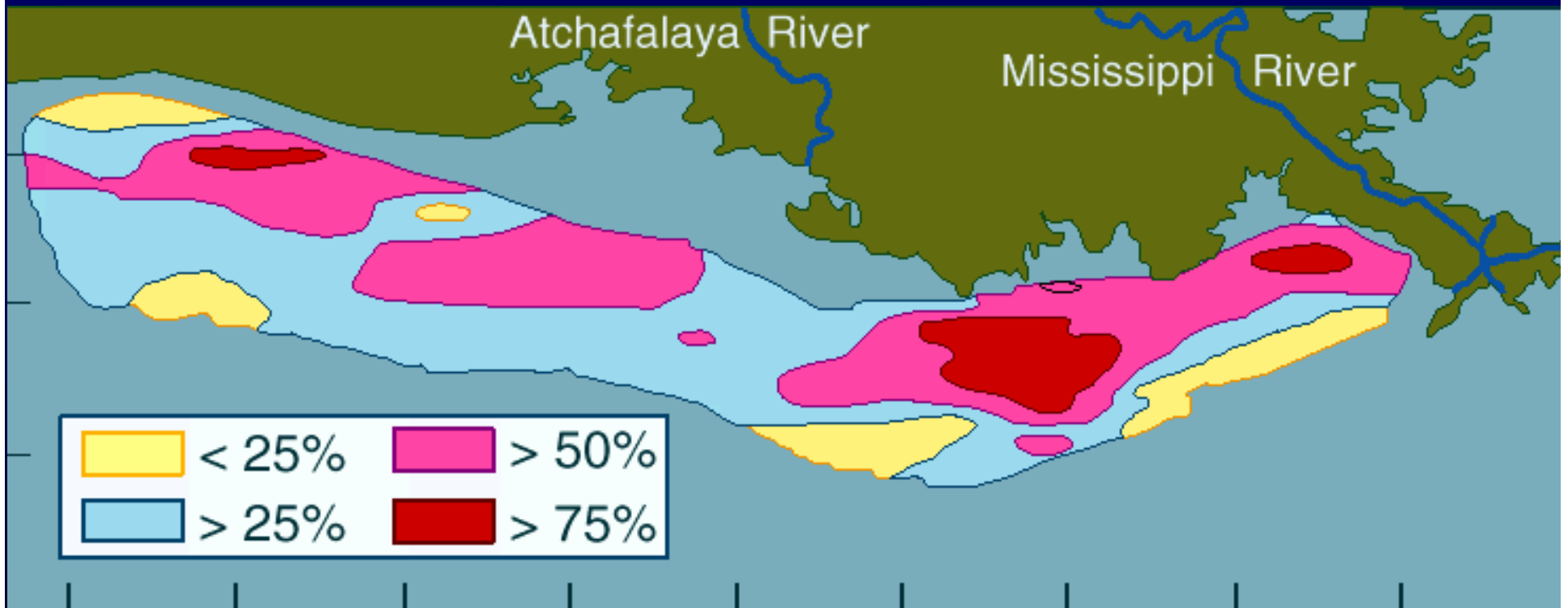
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# Eutrophication – Local Problems



# Hypoxia in the Gulf of Mexico – Downstream Problems

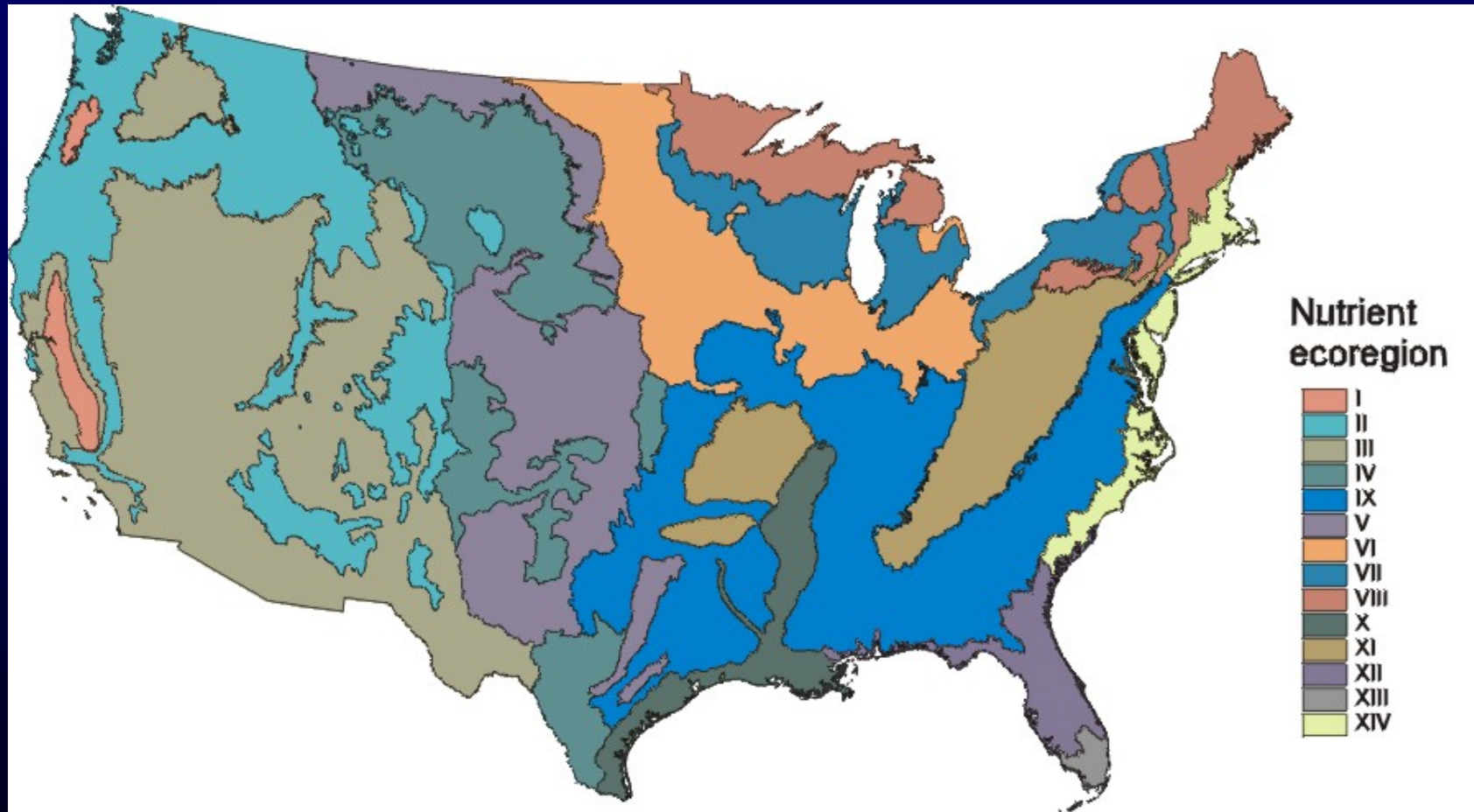


**Frequency of Occurrence 1985 - 1999**

**Rabalais et al., 1999**



# Nutrient Criteria Regionalization Framework:



Initial Classification Scheme for the National Nutrient Strategy  
Based on Omernik Ecoregions

# General Approaches to Define Nutrient Criteria

1. Background or Reference Condition
2. Biological Response – Threshold or Breakpoint

## Two percentile approaches proposed by the EPA to define a background or reference condition

### Reference Site Approach

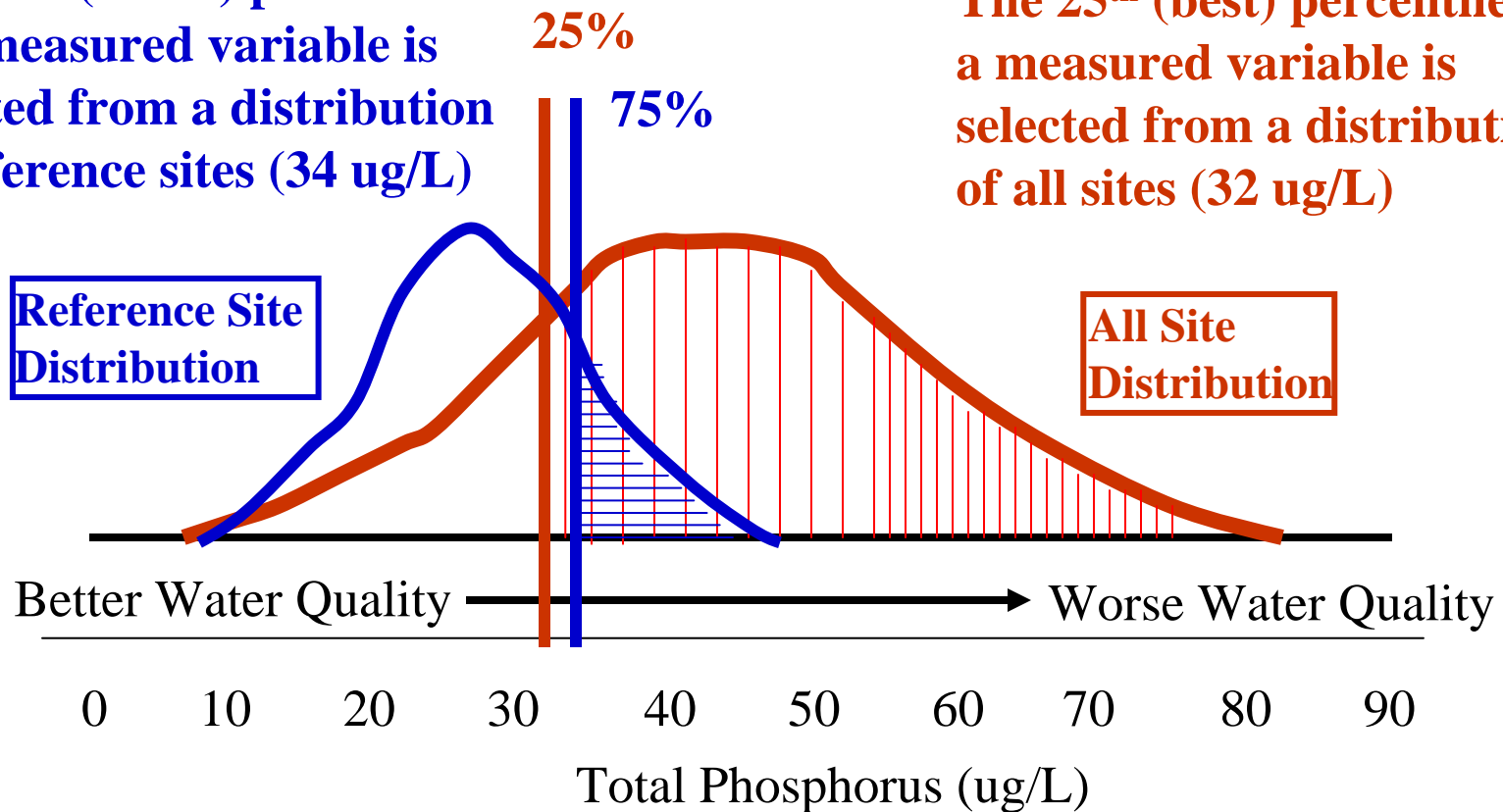
The 75<sup>th</sup> (worst) percentile of a measured variable is selected from a distribution of reference sites (34 ug/L)

Reference Site Distribution

### All Site Approach

The 25<sup>th</sup> (best) percentile of a measured variable is selected from a distribution of all sites (32 ug/L)

All Site Distribution



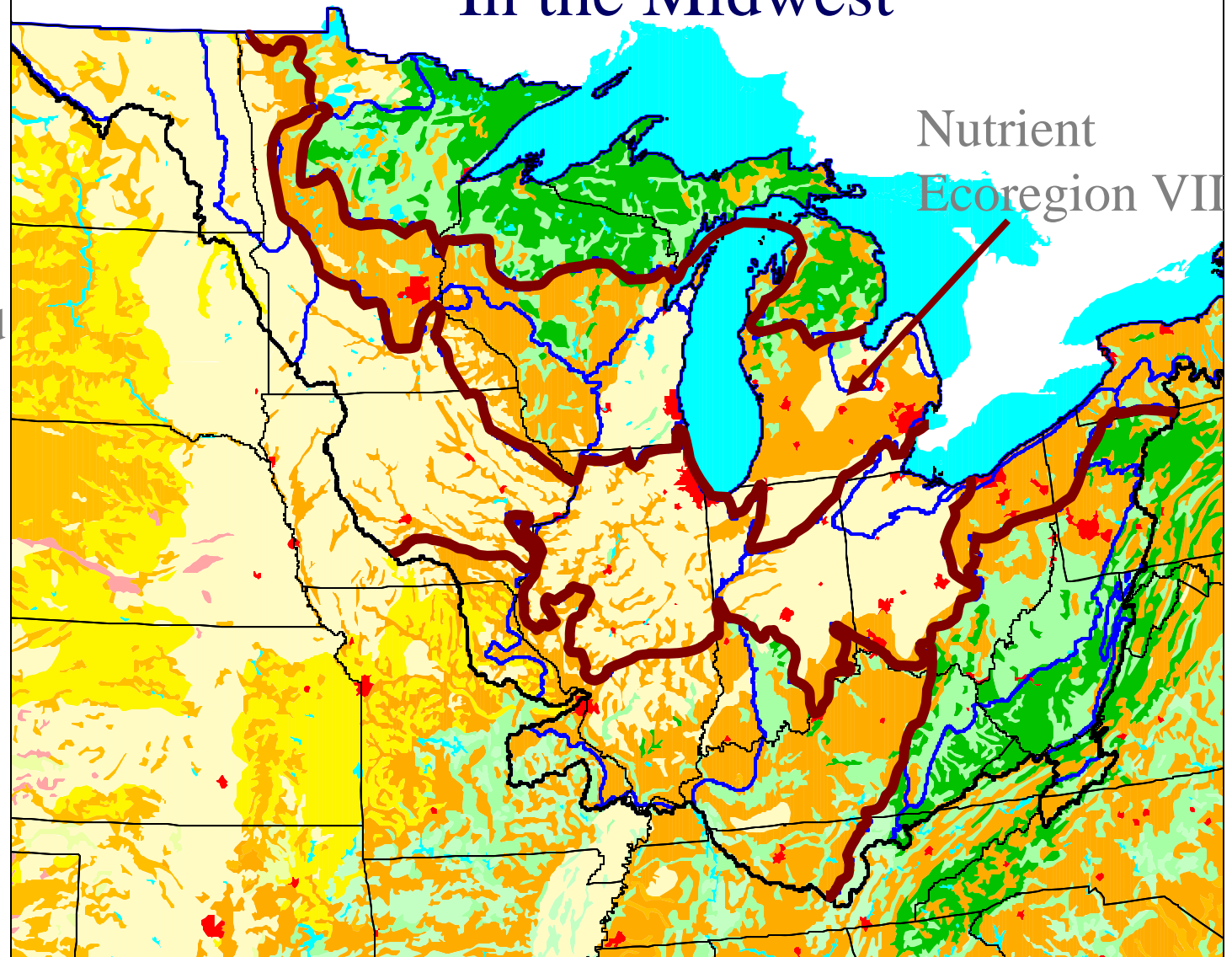
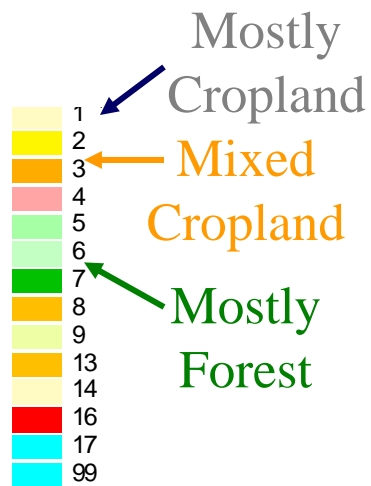
Reference concentrations for total phosphorus, total nitrogen, and suspended chlorophyll a concentrations, and turbidity in various ecoregions (U.S. Environmental Protection Agency, 2000b and 2001)

Region	Total Phosphorus, mg/L	Total Nitrogen (mg/L, Calculated/Reported)	Chlorophyll a (ug/L, Fluorometric/Spectrophotometric/Trichromatic Methods)
Ecoregion 7	0.033	0.54/0.54	1.54/3.50/5.8
NCHF-51	0.029	0.46/0.71	1.03/8.76/--
DFA-52	0.070	1.88/1.51	1.00/2.32/--
SWTP-53	0.080	1.59/1.30	0.55/3.52/--
Ecoregion 8	0.010	0.20/0.38	0.60/2.60/4.3

\*\*\* However, the U.S. EPA does expect various States and Tribes to refine these values

# Difficulties in Using Nutrient Ecoregions In the Midwest

Land Use





# Environmental Phosphorus Zones Delineated with **SPARTA**

## Environmental P Zones

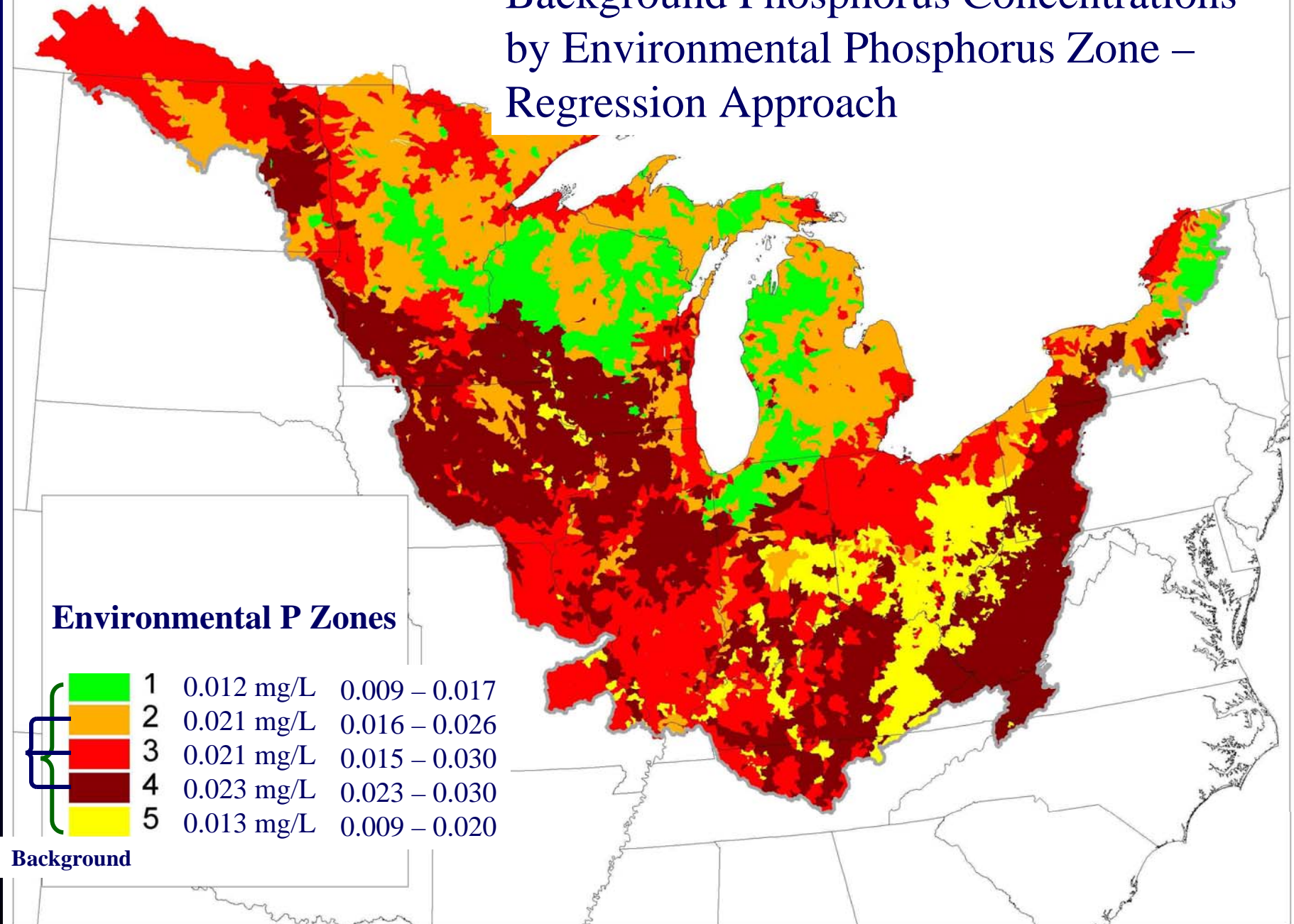


Robertson, et al., 2006

# Background Concentration – Regression Approach (By Zone)

1.  $\text{Ln}(\text{TP}_p) = a + b (\text{Total Ag}) + c (\text{Total Urban})$
2.  $\text{Ln}(\text{TP}_p) = -3.923 + 1.728 (0) + 2.926 (0)$
3.  $\text{Ln}(\text{TP}_B) = -3.923 \text{ SE} = 0.142$
4.  $\text{TP}_B = 0.020 \text{ mg/L}$
5.  $\text{TP}_B = 0.015 - 0.026 \text{ mg/L}$

# Background Phosphorus Concentrations by Environmental Phosphorus Zone – Regression Approach



# Impacts of Nutrients on the Biological Integrity of Wadeable Streams and Nonwadeable Rivers in Wisconsin

Dale Robertson  
David Graczyk



Lizhu Wang  
Paul Garrison  
Brian Weigel



# Refinements For Wisconsin



## Goals of Study



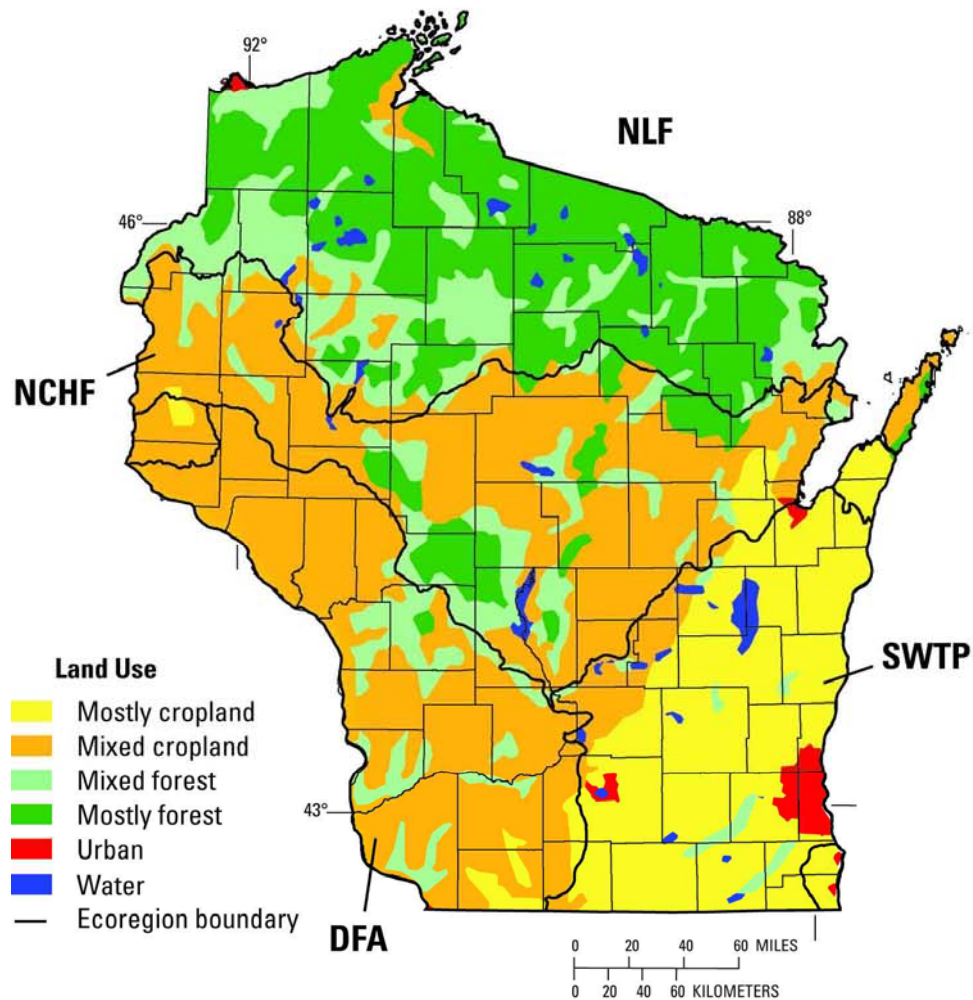
- 1. Describe the distribution of water quality and biology communities in Wisconsin's streams**
- 2. Describe the importance of nutrients to biological community composition**
- 3. Estimate reference conditions and nutrient breakpoints for the State on a "best" regional basis**
- 4. Provide information to help develop refined Nutrient Criteria for Wisconsin**



# Proposed Regionalization Schemes

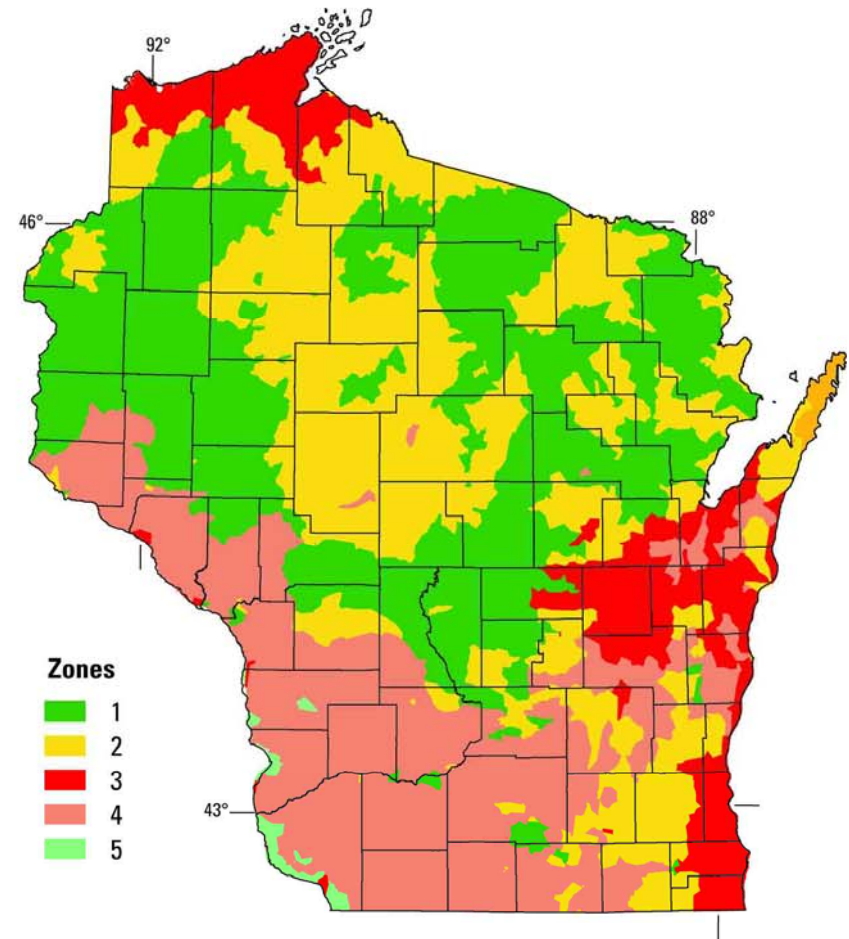
**A.**

**Level III Ecoregions**



**B.**

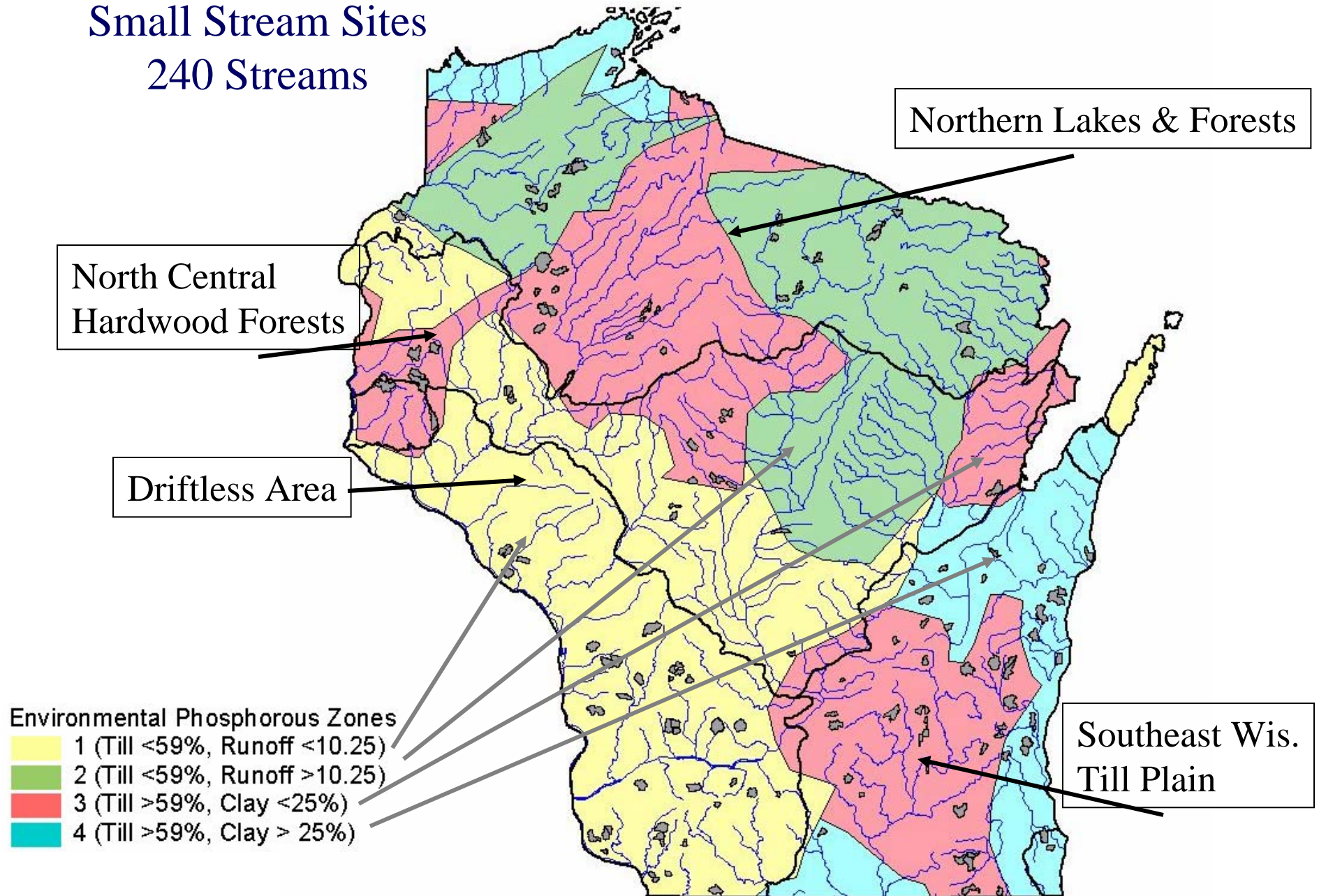
**Environmental Phosphorus Zones**



# Nutrient Impact Study

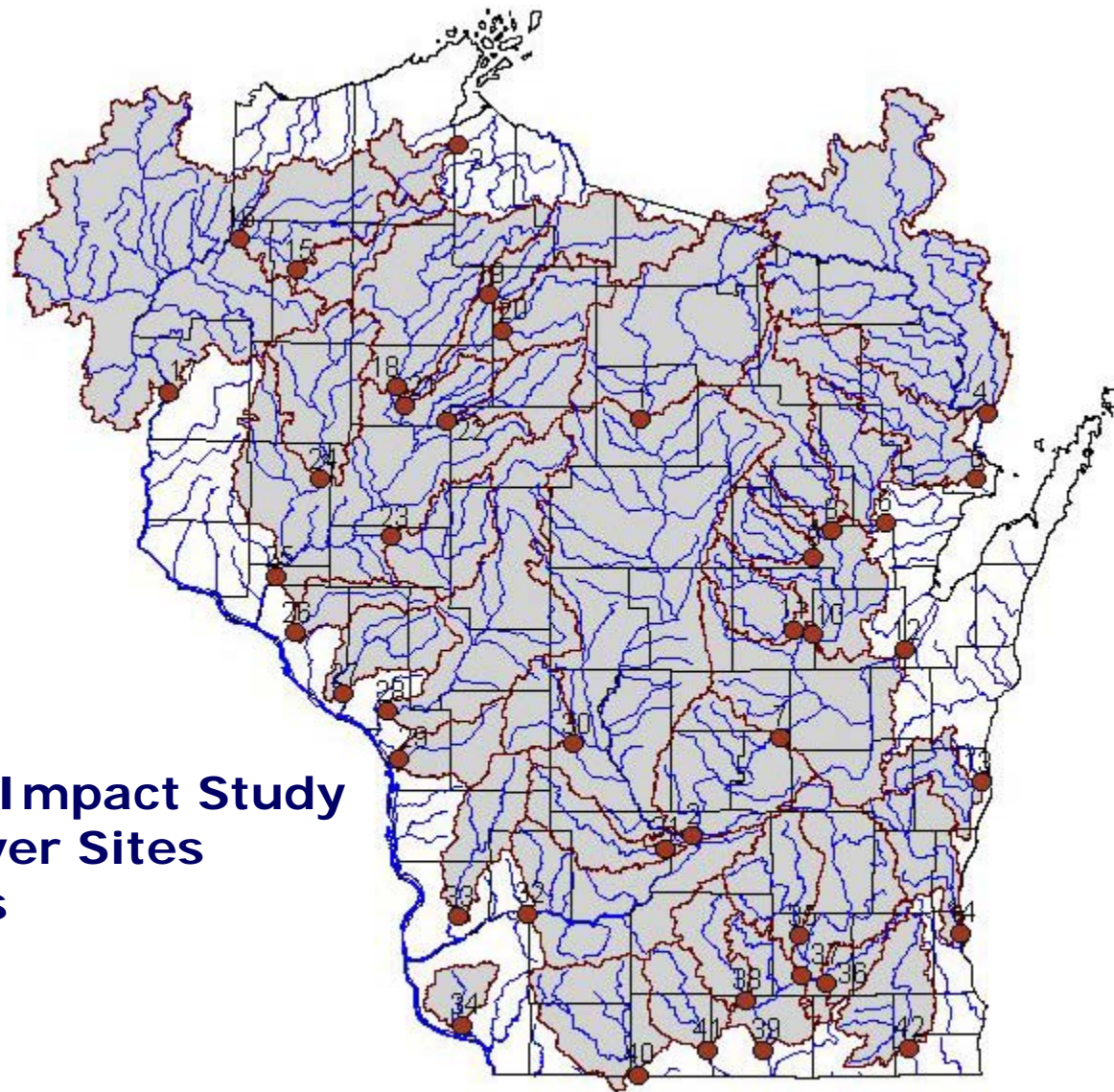
## Small Stream Sites

### 240 Streams



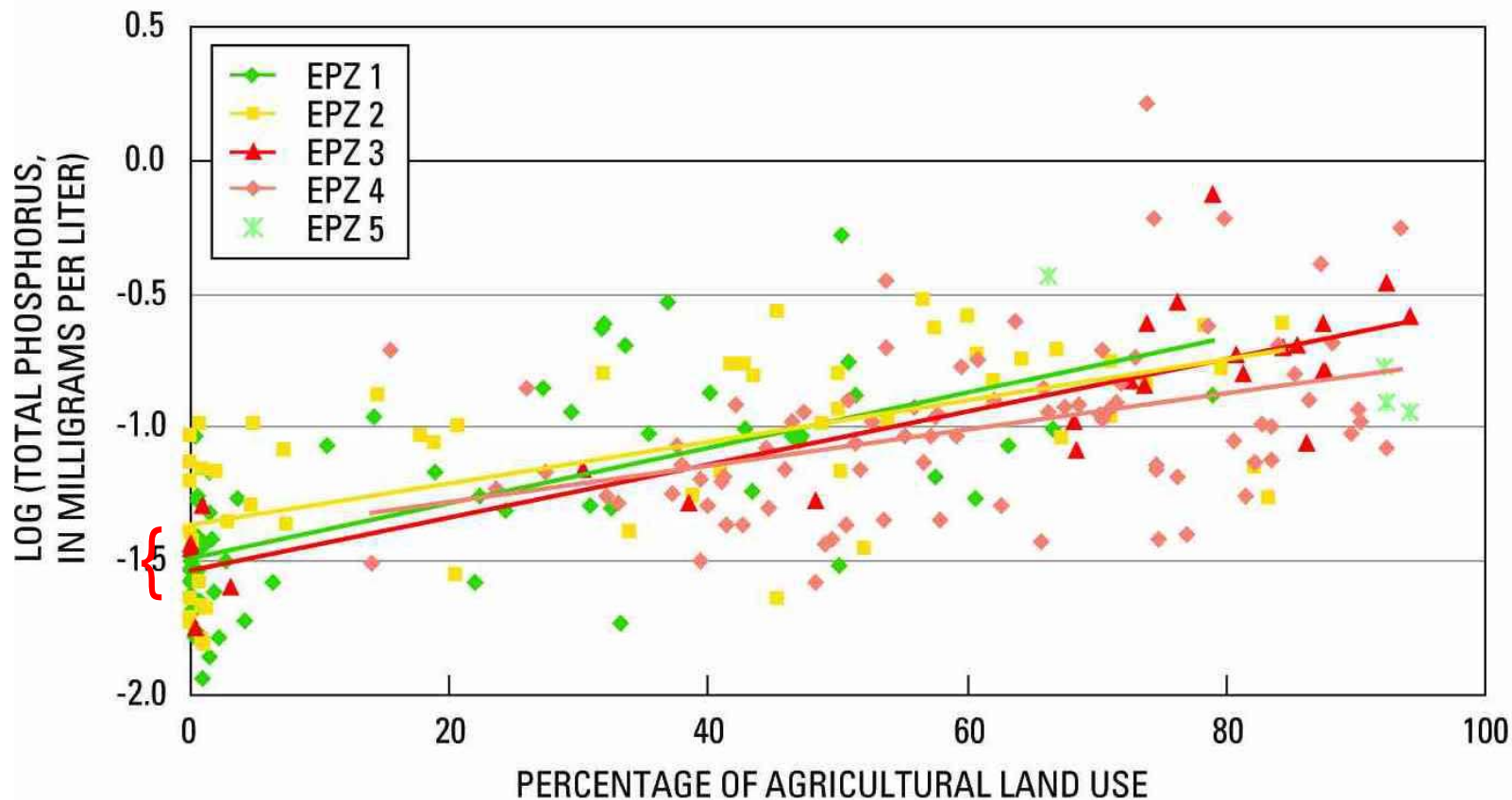


**Nutrient Impact Study  
Large River Sites  
41 Rivers**



0 40 80 120 Kilometers

# Reference Water Quality and Response with the Regression Approach



{ **Reference Concentrations ~ 0.03 – 0.04 mg/L**

Reference concentrations – Regression Approach

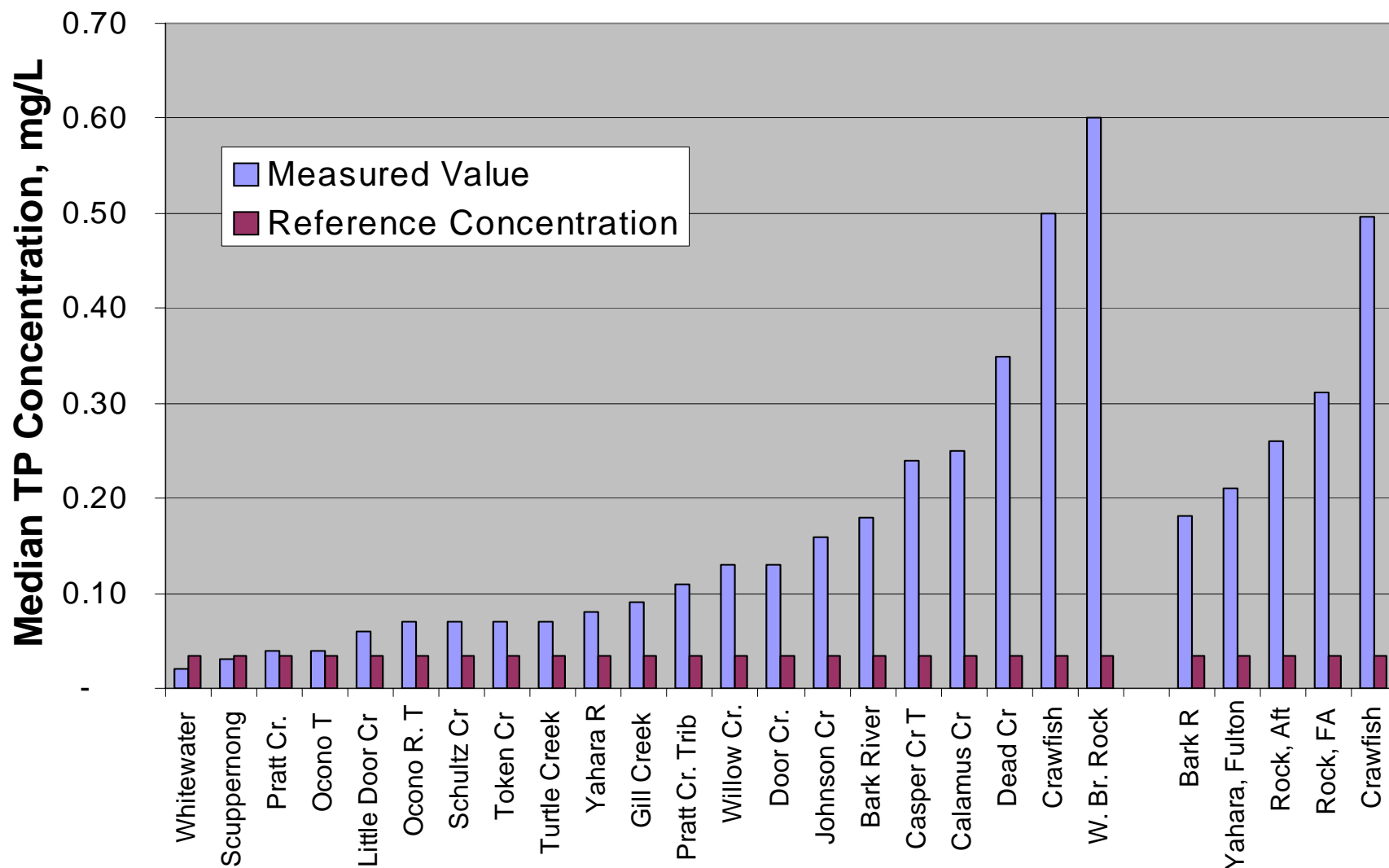
$$\text{Ln}(\text{TP}_p) = a + b (\text{Total Ag}) + c (\text{Total Urban}) + d (\text{PtSources})$$

Reference conditions for Total Phosphorus for all streams and rivers in Wisconsin.

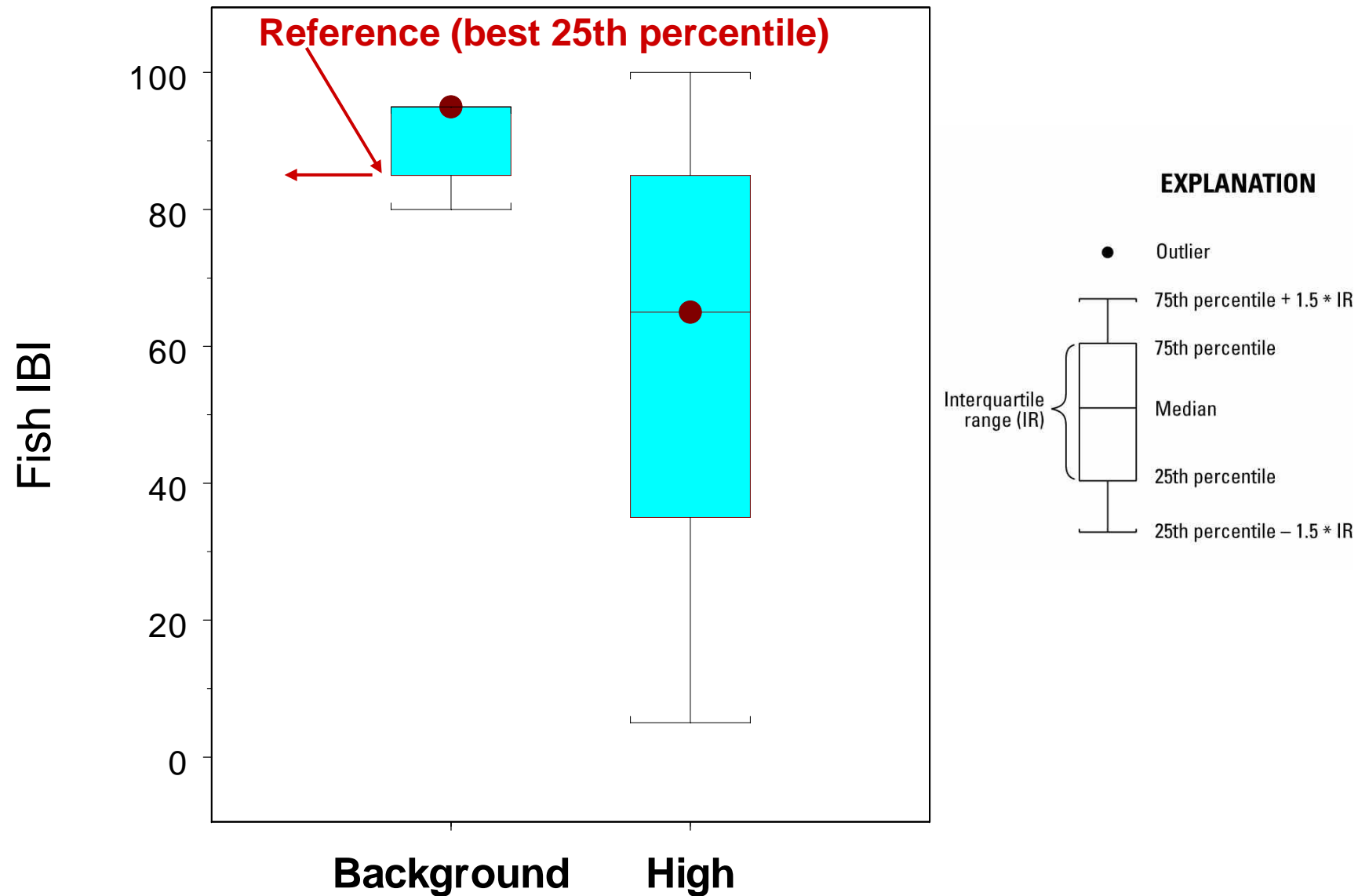
Total Phosphorus (mg/L)		
	Median Background	95 % Confidence Limits for Background
Entire State	<b>0.03 - 0.04</b>	0.04 - 0.06



## Total Phosphorus in Rock River Tributaries Mainstem



# Reference Biological Conditions – Percentile of Reference Streams Approach



# Reference Biological Conditions – Multiple Approaches

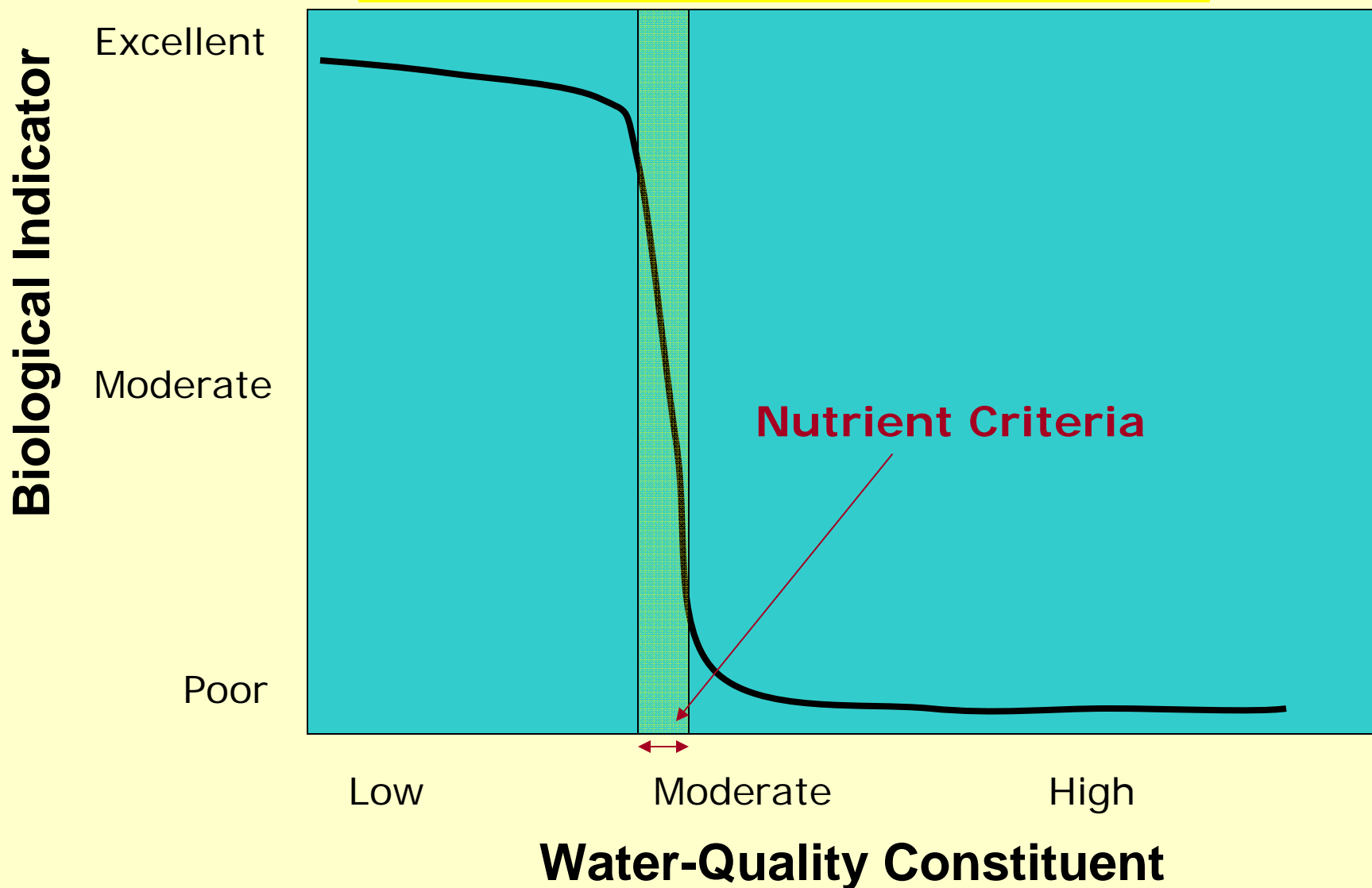
Reference conditions for various biotic indices.

Parameter	Best 25th Percentile of all data	Median of reference sites	Worst 25th percentile of reference sites	Regression approach (mean)	Regression approach (worst 95 percentile)
<b>Macroinvertebrates</b>					
Species richness	38	30	29	38	34
Mean pollution tolerance index	4.8	4.6	4.7	4.8	5.2
% individuals from order Ephemeroptera	31%	45%	31%	29%	20%
Hilsenhoff biotic index	4.9	4.5	4.7	5.0	5.6
% individuals from order Plecoptera	0.8%	0.7%	0.3%	1.3%	0.3%
% individuals that are scrapers	12.5%	17.4%	11.8%	13.7%	7.0%
<b>Fish</b>					
Wisconsin large river index of biotic integrity	90	95	88	87	75
% suckers by weight	72%	84%	77%	67%	53%
# of species intolerant of degradation	3	4	3.3	3.7	3.0
% individuals that are river species	39%	44%	30%	39%	29%
# river species	7	6	4.3	6.4	5.0
% individuals that are lithophilic spawners	73%	88%	85%	73%	63%

Note: red values are not significant at  $p < 0.1$

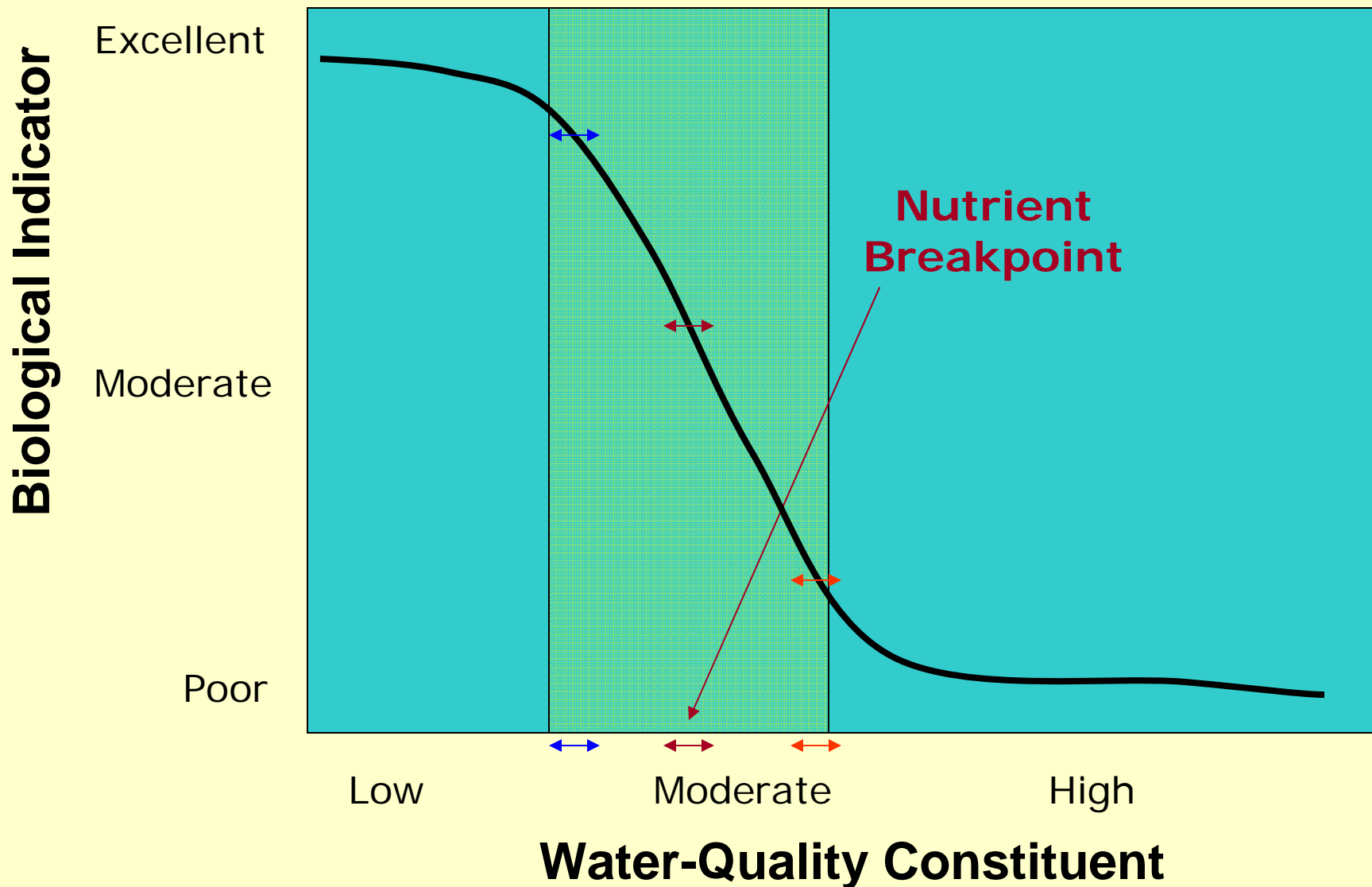
# Theoretical Biological Response to Increases in Nutrient Concentrations

## Threshold/Breakpoint Approach



# Theoretical Biological Response to Increases in Nutrient Concentrations

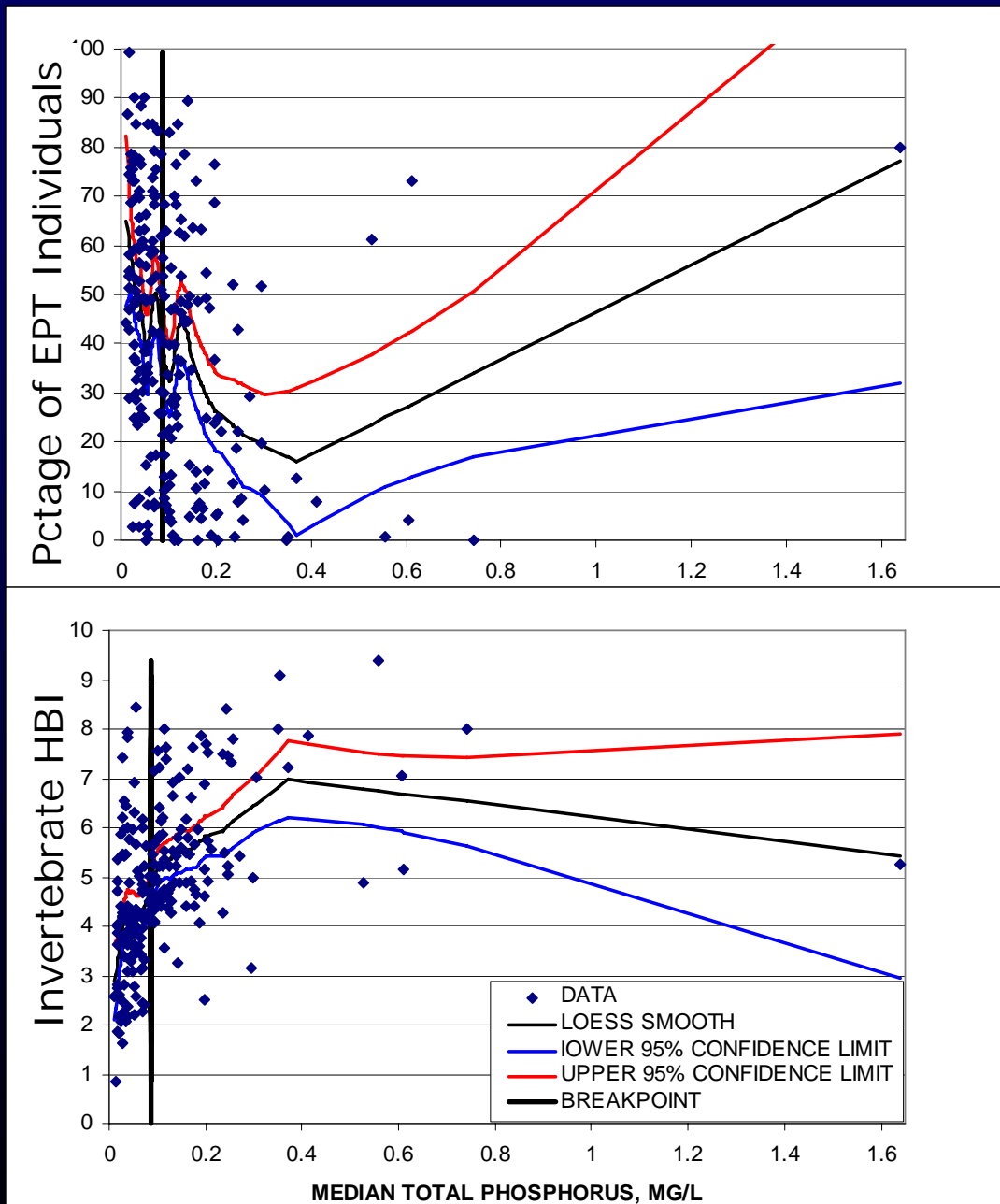
## Threshold/Breakpoint Approach



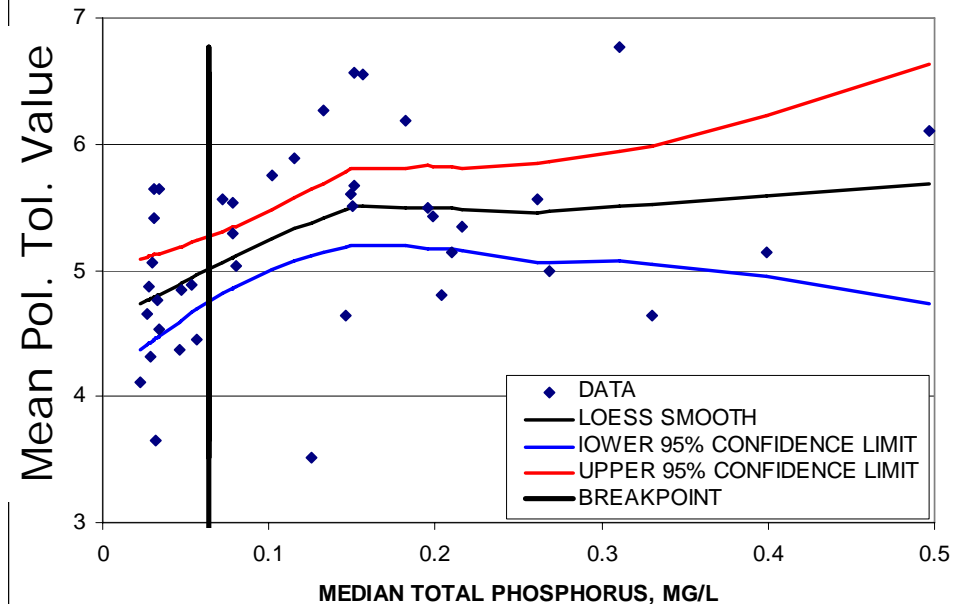
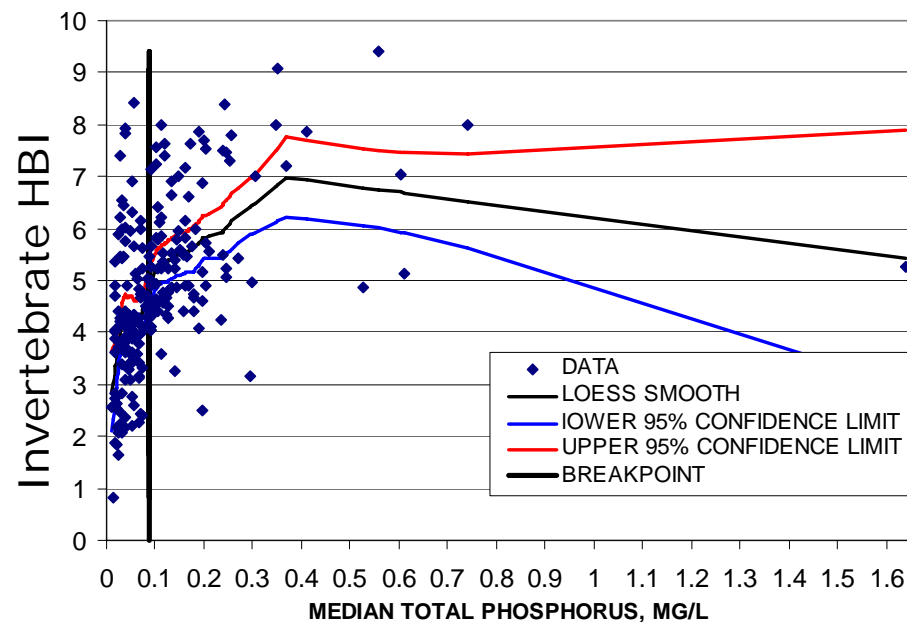
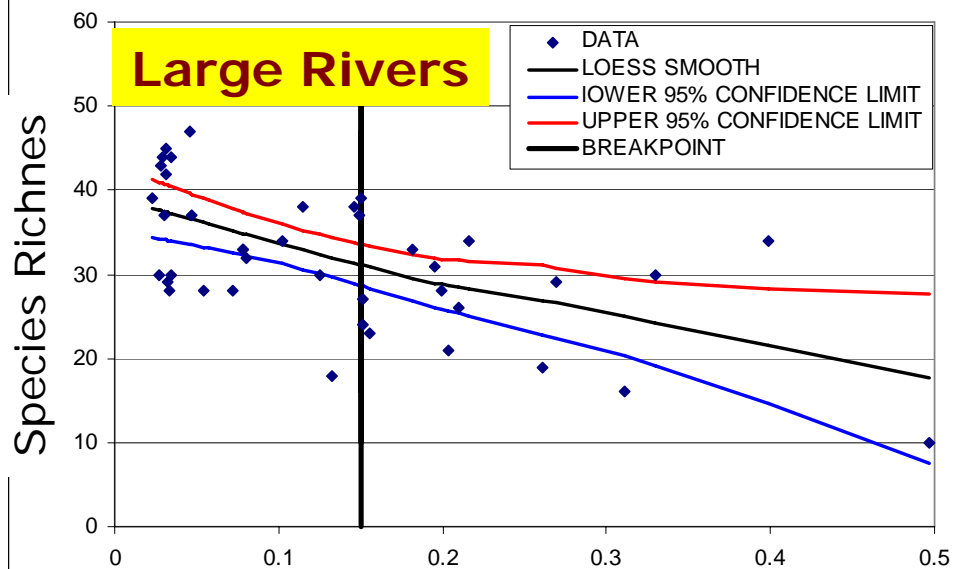
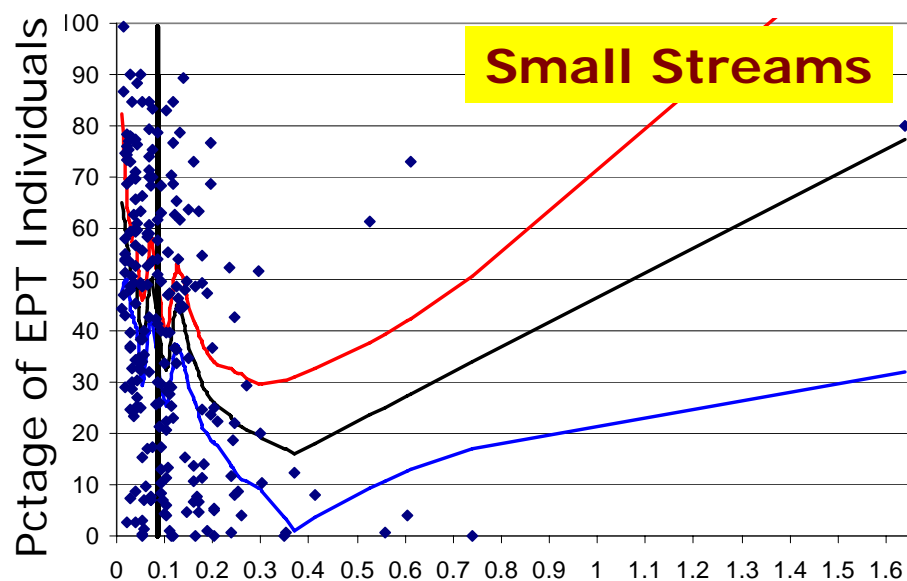


# Breakpoints in Macroinvertebrate Response

## Small Streams

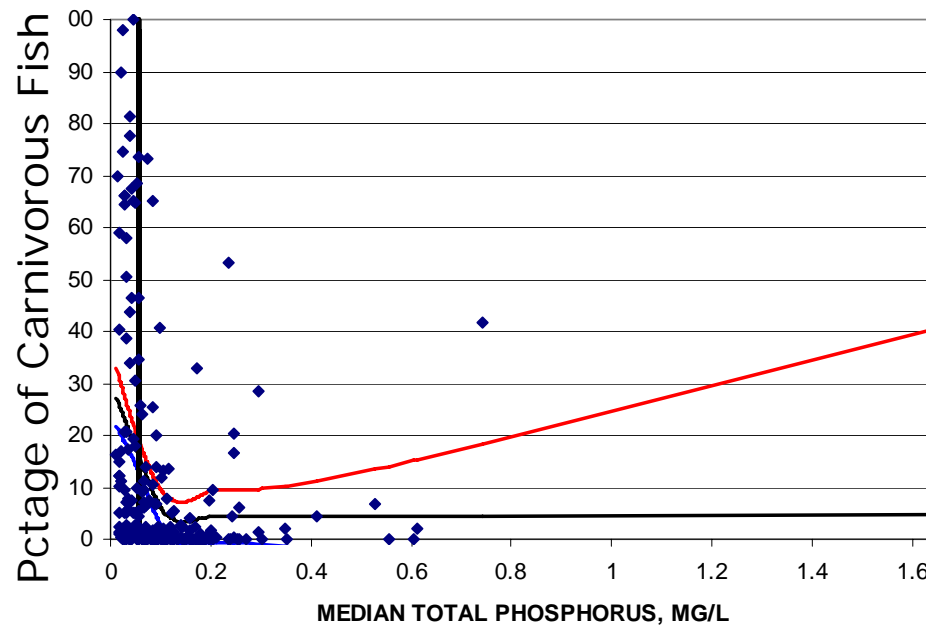
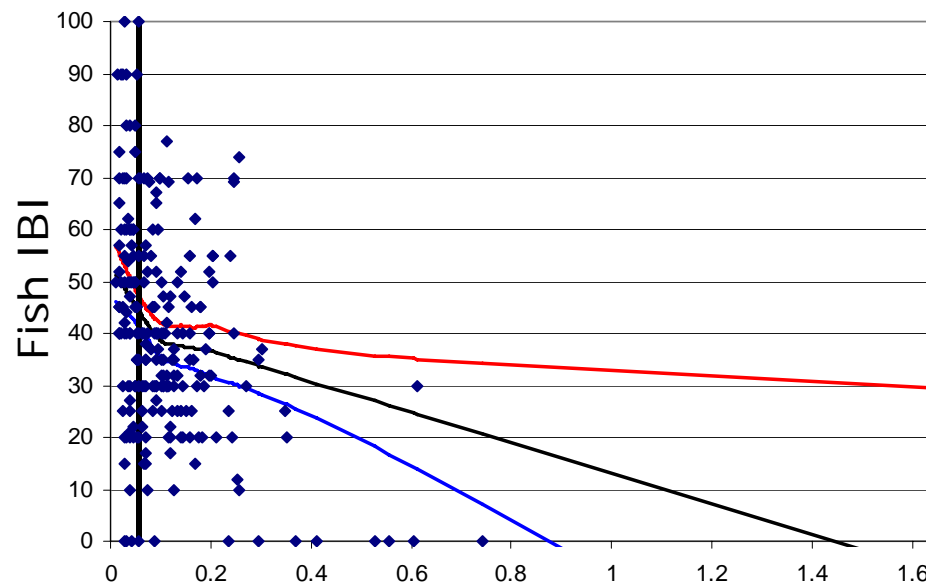


# Breakpoints in Macroinvertebrate Response



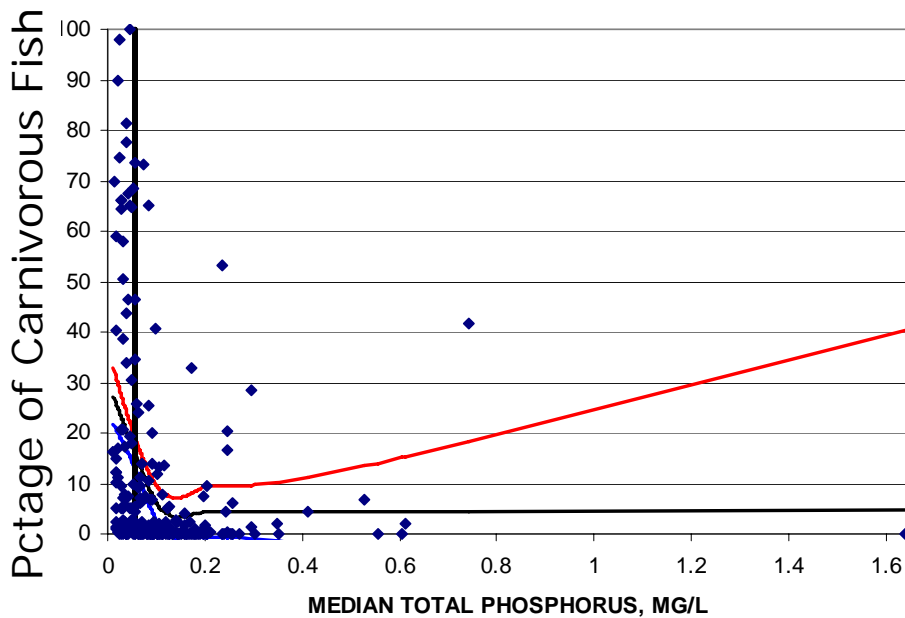
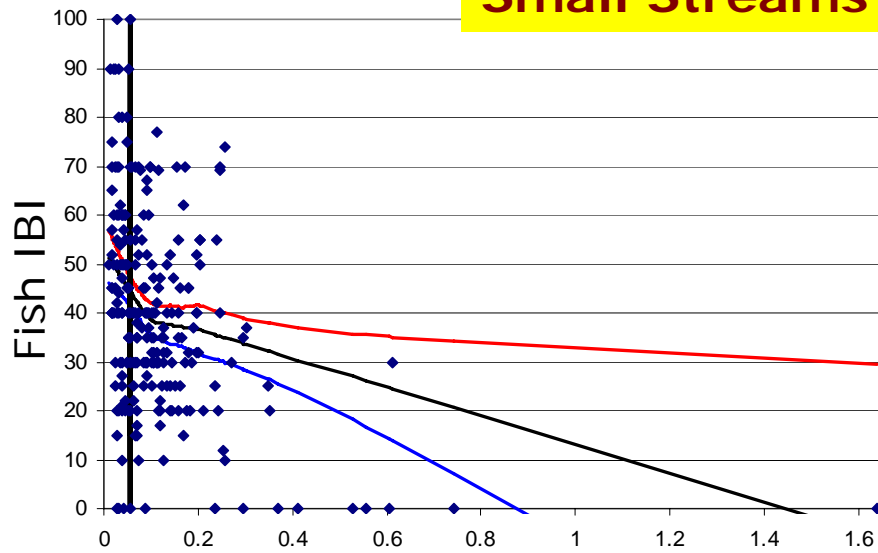
# Breakpoints in Fish Response

Small Streams

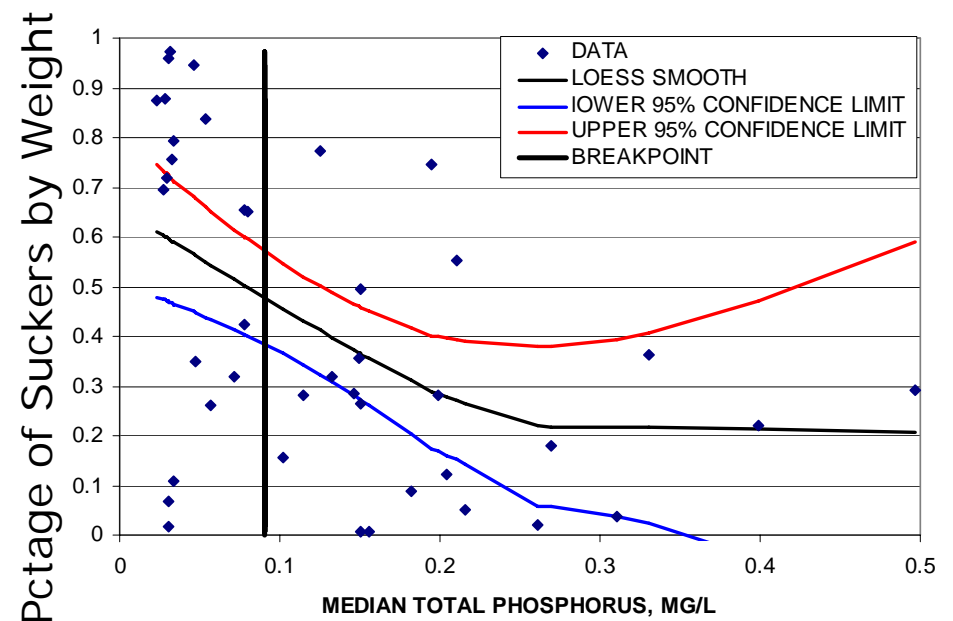
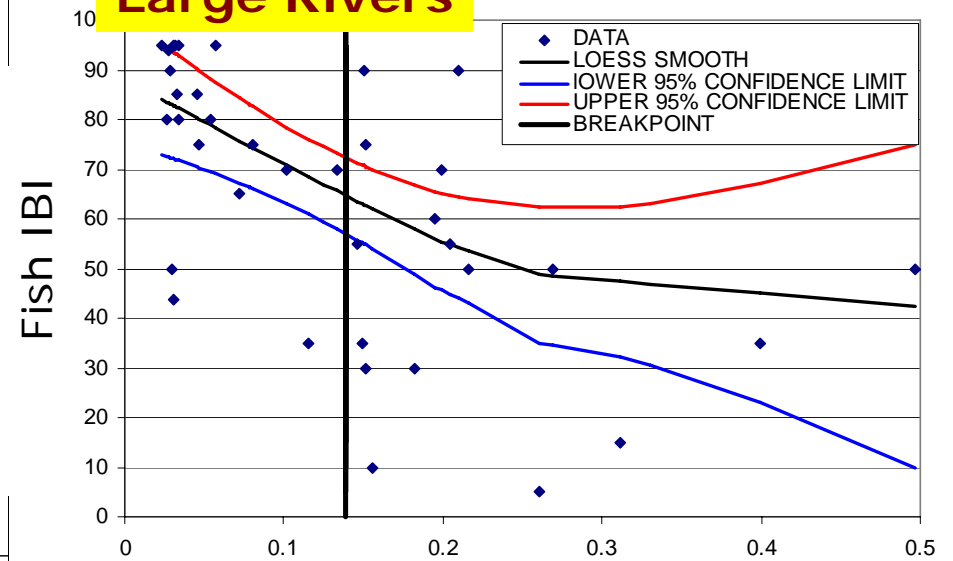


# Breakpoints in Fish Response

## Small Streams



## Large Rivers



# Breakpoints / Thresholds for Biological Response

Thresholds or break points in the response in water quality and various biological indices to changes in Phosphorus concentrations (in mg/L)

Biological Indices	Total Phosphorus
<b>Water Quality</b>	
Secchi Depth	0.106
Suspended Chlorophyll	0.070
<b>Benthic Chlorophyll and Diatoms</b>	
Benthic Chlorophyll	0.039
Nutrient Index	0.057
Siltation Index	0.074
Biotic Index	0.072
<b>Macroinvertebrates</b>	
Hilsenhoff Biotic Index	0.088
Percent EPT individuals	0.087
Percent EPT taxa	0.091
<b>Fish</b>	
Fish Index of Biotic Integrity	0.055
Percent carnivorous fish	0.055
Percent intolerant fish	0.067

Wadeable Streams  
Range  
0.039 – 0.106 mg/L



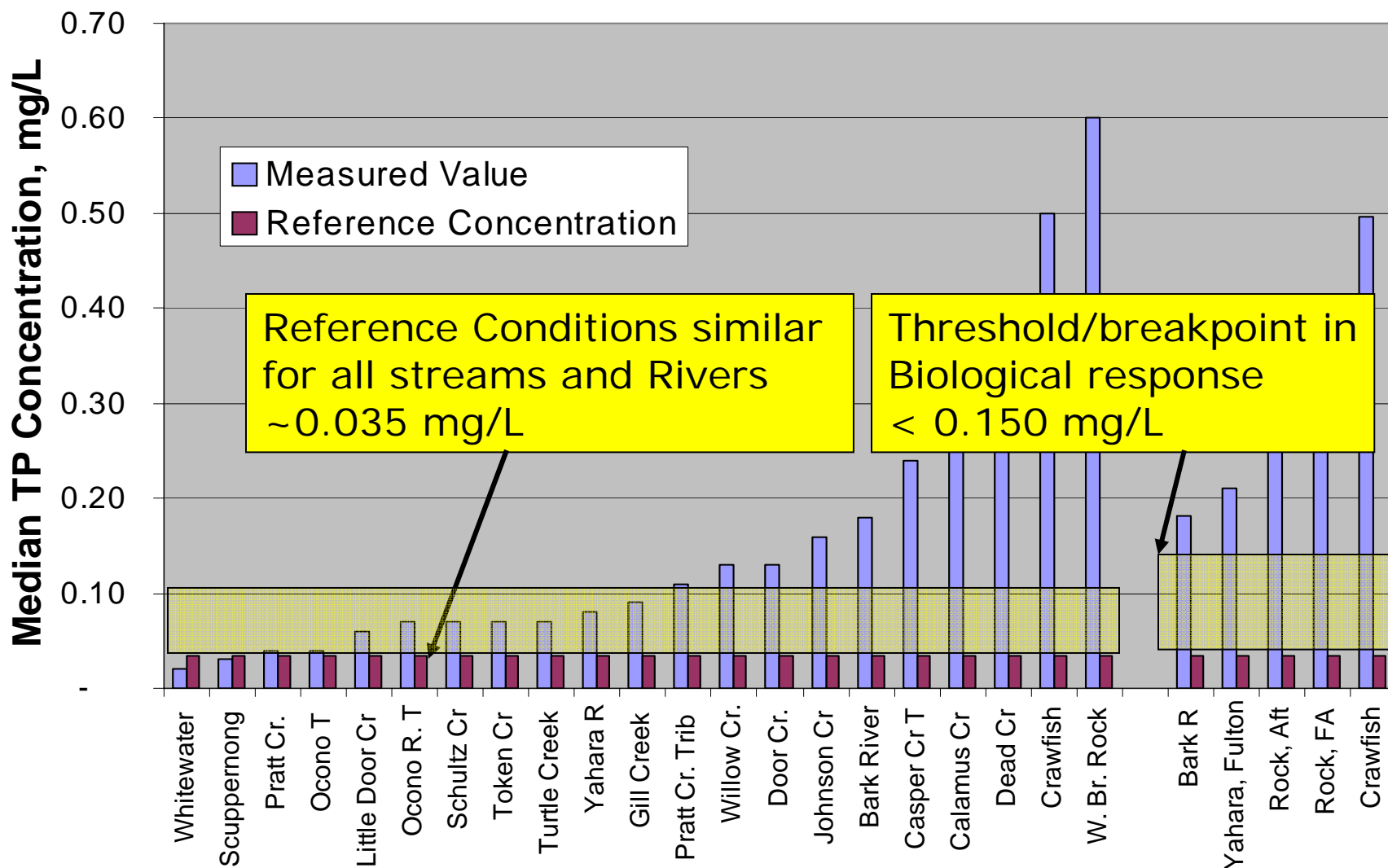
# Breakpoints / Thresholds for Biological Response

Thresholds or break points in the responses in water quality and various biological indices to changes in Total Phosphorus concentrations for nonwadeable streams in Wisconsin

<b>Biological Indices</b>	<b>Total Phosphorus</b>
<b>Water Quality</b>	
Secchi Depth	0.091
Suspended Chl. - Log	0.064
<b>Macroinvertebrates</b>	
Species richness	0.150
Mean pollution tolerance index	0.064
Percent of individuals from order Ephemeroptera	0.040
Hilsenhoff biotic index	0.150
Percent of individuals from order Plecoptera	0.148
Percent of individuals that are scrapers	0.034
<b>Fish</b>	
Wisconsin large river index of biotic integrity	0.139
Percent of Weight that is Suckers	0.091
Number of Intolerant Species	0.139
Percent of individuals that are river species	0.079
Number of River Species	0.147
Percent of individuals that are lithophilic spawners	0.055

Nonwadeable Rivers  
Range  
0.04 – 0.15 mg/L

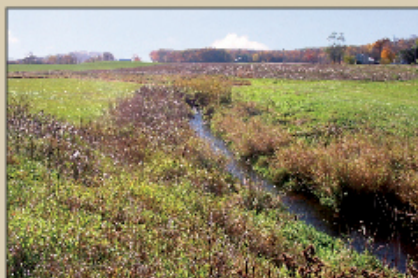
## Total Phosphorus in Rock River Tributaries Mainstem





In cooperation with the Wisconsin Department of Natural Resources

## Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin



Professional Paper 1722

U.S. Department of the Interior  
U.S. Geological Survey

Available at <http://pubs.usgs.gov/pp/pp1722/>

Robertson, D.M., Graczyk, D.J., Garrison, P.J., Wang, L., LaLiberte, G., and Bannerman, R., 2006.

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